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Fissile Material Disposition Program

MOX Irradiation, Feedstock, and Transportation

ARIES Oxide Production Program

Legacy Risk Reduction Project

Prepared by Tracy Wenz, Engineer

FS65 DISPOSITION OPTIONS REPORT

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Background

The fuel rods stored in FS65 containers at Los Alamos National Laboratory (LANL) were received by LANL in 2005 as part of the Lead Test Assembly (LTA) program to support Nuclear Regulatory Commission (NRC) fuel licensing in light water reactors (LWR). This effort is part of the larger program to implement the 1994 agreement between the United States (US) and Russia to disposition surplus Weapons Grade Plutonium (WGPu). The disposition plan at the time was to make mixed oxide (MOX) fuel assemblies with the pure WGPu and then burn the fuel in commercial power reactors. Since the US stopped MOX fuel production in the late 1970's, it was necessary to re-establish the capability to make MOX fuel using WGPu.^{1,2}

Development of MOX fuel made of depleted uranium and WGPu that could be used in existing light water commercial reactors began at LANL in 1994.² In January 2000, LANL sent MOX fuel pellets to Canada in support of the PARALLEX test that used MOX fuel manufactured from WGPu by the US and Russia for irradiation testing in a Canadian reactor. The Canadians were considering burning the MOX from WGPu in their CANDU reactors. In addition, the MOX LTA program was tasked with designing and fabricating lead test assemblies that would undergo fuel qualification to meet NRC requirements for use in US commercial reactors. In this process, LANL teamed with MOX specialists from Duke Engineering Services, COGEMA, and Stone and Webster (DCS). The baseline project plan for fabrication was submitted to the Department of Energy (DOE) in April 2000. By May 2000, DOE decided not to fabricate the fuel at LANL because of the schedule risks associated with removing and installing equipment and implementing a new production capability for a project with a compressed execution schedule. In addition, the need to bring foreign nationals into the plutonium (Pu) facility to oversee all stages of fuel production, a requirement by the NRC as part of the fuel certification process^{1,6}, would be problematic. Consequently, the EuroFab project in which US Pu was sent to France for MOX fuel fabrication in an existing facility was initiated.

The Pu oxide produced by the Actinide Recovery and Integrated Extraction System (ARIES) at LANL was sent to France in the summer of 2004 where it was used to manufacture MOX fuel assemblies. Four FS65 containers loaded with MOX fuel assemblies fabricated in France were delivered to Catawba Nuclear Power Station in South Carolina in April 2005. The four fuel assemblies were placed in the Catawba Unit 1 reactor. The first 180-day irradiation was completed in the fall of 2006. Poolside inspection of the assemblies showed no deviations from specifications. The second 180-day irradiation was completed in the spring of 2008. Poolside inspections were again performed on the fuel assemblies. Only one parameter was outside of the tolerance of the fuel specification – the overall fuel assembly length had increased beyond acceptable tolerances. Consequently, a third irradiation cycle was not performed. AREVA (formerly, COGEMA) stated in their report that skipping the third, optional, cycle did not impact the fuel qualification process.⁵ The irradiated fuel remains in a spent fuel storage pond at the Catawba site.

Two additional FS65s included in the shipment from France contained excess fuel rods that were sent to LANL for storage until the MOX Fuel Fabrication Facility (MFFF) at the Savannah River Site (SRS) could accept them. This material comprised 713 kilograms of Uranium and 28 kilograms of Pu. The extra fuel material would be used to feed the pellet fabrication process at MFFF.^{3,4} Currently, LANL performs periodic visual inspections and monitoring of the FS65s.

This report outlines the options for dispositioning the MOX fuel stored in FS65 containers at LANL. Additional discussion regarding the support equipment for loading and unloading the FS65 transport containers is included at the end of the report.

Fuel Disposition Options

Originally, LANL was tasked with sending eight rods to the SRS MFFF for hot startup testing then sending the remaining fuel rods at a later date. MFFF needed both rods and pellets with three different Pu concentrations (2.4%, 3.3% and 4.9%) for their startup testing. In 2009, it was decided that the rods could not be opened at LANL due to plutonium-gallium (Pu-Ga) contamination issues, so the eight rods would be sent to Oak Ridge National Laboratory (ORNL), where the pellets would be removed from three of the rods and then packaged for shipment to MFFF along with the remaining five intact rods. This change allowed ORNL to retain archive samples of the pellets, which was an NRC requirement.⁷

Today, the MFFF construction completion date continues to be delayed pending a programmatic reevaluation of disposition options for the surplus Pu.⁸ With this potential change in approach, the following disposition options for the FS65 material are discussed:

1. Ship fuel rods to SRS for eventual use in the MFFF once they are able to receive the fuel
2. Dispose of fuel rods as waste at the Waste Isolation Pilot Plant (WIPP)
3. Ship eight fuel rods to ORNL and the remaining fuel to SRS for eventual use in the MFFF
4. Repackage pellets into 3013 containers and ship the containers to SRS for storage
5. Dispose of the fuel rods through the Material Recovery and Recycle (MR&R) program

Option 1: Ship fuel rods to SRS once they are able to receive the fuel

Shipping the fuel in the unopened FS65 containers to SRS is the option that requires the least expenditure and labor at LANL. This was the plan when the Lead Test Assembly program was completed and the extra fuel was sent to LANL for temporary storage until the MFFF could be licensed to receive the material. MFFF would then unload the pellets from the fuel rods and use the pellets as feed material in the pellet fabrication process. However, construction schedules continue to be delayed, thus preventing MFFF from accepting the material. If the MOX program continues, the following tasks are needed under this activity:

- Restart maintenance on the FS65 containers
- Submit a request to the NRC for a one-time exemption of use of the FS65 shipping container or a national security exemption
- Develop Material Control and Accountability (MC&A) Shipper/Receiver agreement
- Develop work procedures to move and load FS65 containers onto a transport vehicle
- Move and load the FS65 containers for shipment
- Ship the FS65 containers to SRS

Should DOE decide that production of MOX fuel is not a viable option in the future, this option would no longer be applicable unless SRS could accept the material for long-term storage at K-Area or another location.

Option 2 : Ship fuel rods as waste to WIPP

When this option was first considered, there was discussion that the FS65s could be qualified for direct burial at WIPP without the need for repackaging. To use the FS65s, a few facility modifications would be needed to qualify them as disposal containers for WIPP and move them into the drifts, which at the time seemed possible to accomplish. Upon further inquiry about this option, qualifying the FS65 container for direct disposal has become prohibitively difficult in the aftermath of the February 2014 radiation release from a breached drum at WIPP.¹⁰ Consequently, sending the fuel rods to WIPP in a waste acceptance-compliant configuration will require reducing the length of the fuel rods so that they will fit into an already approved WIPP container. Either the pipe overpacks (POCs) or criticality control overpacks (CCOs) are the recommended packaging options for disposition at WIPP.⁹

Since the individual fuel rods will have to be handled, MC&A measurement requirements will increase, new criticality safety evaluations will be required, and a new process to size-reduce the fuel rods will require development. To execute this option, the following are needed:

- Develop MC&A requirements for the measurement of the fuel once it is unpacked from the FS65 containers
- Develop Criticality Safety Evaluations for handling the rod box, the fuel assembly, individual fuel rods, and performing MC&A measurements
- Develop work procedures to unload fuel rods from FS65 containers and handle the fuel outside of the containers
- Establish storage requirements when the fuel is outside of an FS65 container
- Establish capability to chop the fuel rods into smaller pieces and load into WIPP approved containers (location, containment, criticality safety evaluations, procedures, measurement requirements, new operation startup activities)
- Conduct packaging into WIPP-approved transport/disposal containers
- Characterize the filled WIPP-approved containers at LANL
- Ship the characterized WIPP-approved containers to WIPP
- Dispose of FS65 container in which the fuel was stored

Option 3: Ship Eight Fuel Rods to ORNL and the Remaining Fuel to SRS

The original plan in 2009 was to send eight fuel rods to ORNL where the pellets would be removed from three of the fuel rods then send the remaining rods and repacked pellets to MFFF. The limited set of material was needed for startup activities. The remaining FS65 material would stay at LANL until MFFF was ready to receive it. Given the changes in schedule for the MFFF, sending the eight fuel rods separately from the rest of the material may no longer be necessary. The capability to remove pellets from a fuel rod may be available at LANL by the time the fuel needs to ship to MFFF, given that the MR&R program will need to dispose of fuel rods unrelated to the FS65 material at some time in the future. However, to execute this option per the original plan, the following are needed:

- Confirm whether the ORNL process to remove pellets from fuel rods is operational
- Develop MC&A requirements for the measurement of the fuel once it is unpacked from the FS65 containers
- Develop Criticality Safety Evaluations for handling the rod box, individual fuel rods, and performing MC&A measurements
- Develop work procedures to unload and load the rod box from the FS65 container, unload fuel from the rod box, handle the fuel outside of the FS65 containers, perform MC&A measurements, and load a NAC-LWT
- Establish storage requirements when the fuel is outside of an FS65 container
- Develop MC&A Shipper/Receiver agreement with ORNL and, eventually, MFFF
- Submit a request to the NRC for a one-time use exemption to use the FS65 shipping container or a national security exemption
- Restart maintenance on FS65 equipment
- Procure a NAC-LWT licensed shipping container for the eight fuel rods
- Move and load the FS65 containers for shipment
- Move and load the NAC-LWT for shipment
- Ship the NAC-LWT to ORNL
- Ship the FS65s to MFFF

Should DOE decide that production of MOX fuel is not a viable option in the future, this option would no longer be applicable.

Option 4: Repackage pellets into 3013 containers and ship the containers to SRS for storage

If fuel material is needed for MFFF but storing the MOX in the form of fuel rods is not possible at SRS, the pellets could be unloaded from the fuel rods and packaged into 3013 long term storage containers. This option is the most expensive because it includes developing a process to remove pellets from fuel rods and packaging them into 3013 cans. To execute this option as described, the following are needed:

- Develop MC&A requirements for the measurement of the fuel once it is unpacked from the FS65 containers
- Develop Criticality Safety Evaluations for handling the rod box, the fuel assembly, individual fuel rods and performing MC&A measurements
- Develop work procedures to unload fuel rods from FS65 containers, handle the fuel outside of the containers, and perform MC&A measurements
- Establish storage requirements when the fuel is outside of an FS65 container
- Establish capability to unload the pellets from the fuel rods (location, containment, criticality safety evaluations, procedures, measurement requirements, new operation startup activities)
- Package the pellets into 3013 containers
- Ship the pellets to SRS
- Package waste into WIPP-approved containers at LANL
- Ship the characterized WIPP-approved containers to WIPP
- Dispose of the FS65 containers in which the fuel was stored

Should DOE decide that production of MOX fuel is not a viable option in the future, this option would no longer be applicable.

Option 5: Dispose of the fuel rods through the MR&R Program

The MR&R Program is reducing the amount of material stored at LANL by processing orphaned materials that are no longer useful for programmatic missions into a form that can be more easily disposed of as waste. This program will be dealing with all types of material including MOX fuel rods that are not related to the FS65 effort. Consequently, MR&R will have to develop a process for size reducing fuel assemblies for packaging into WIPP certified containers, which it currently anticipates doing in the FY18-19 time frame. If it is determined that the LTA MOX fuel rods are to be disposed of as waste, the two programs should coordinate development of the size reduction process that both may need. The LTA fuel rods would drive the process design since they are longer than the MR&R rods. Possible locations have been identified to perform the size reduction work, which would require erecting tenting around gloveboxes both due to the fuel rod size and for entry of material into gloveboxes. To execute this option as described, the following are needed:

- Develop MC&A requirements for the measurement of the fuel once it is unpacked from the FS65 containers
- Develop Criticality Safety Evaluations for handling the rod box, the fuel assembly, and individual fuel rods, and performing MC&A measurements
- Develop work procedures to unload fuel rods from FS65 containers and handle the fuel outside of the FS65 containers
- Establish storage requirements when the fuel is outside of an FS65 container

- Establish capability to unload the pellets from the fuel rods and size-reduce the empty fuel rods to fit into WIPP-approved containers (including a work location, containment, criticality safety evaluations, procedures, measurement requirements, new operation startup activities)
- Package everything into WIPP-approved containers
- Characterize the filled WIPP-approved containers
- Ship the characterized waste containers to WIPP
- Dispose of the FS65 container in which the fuel was stored

Summary of Fuel Disposition Options

The table below summarizes the disposition options. The least expensive approach, if MOX fuel production continues to be the selected path for surplus Pu, is Option 1 in which the material continues to be stored at LANL until MFFF is licensed to receive the fuel. All other options require at least one FS65 to be unloaded, which adds MC&A and Criticality Safety costs. Options 2, 4, and 5 require the capability to unload fuel pellets from the fuel rods. This capability is not currently operating at LANL and has all of the issues associated with starting up a new process. MR&R will also need to develop the capability to process MOX fuel rods, so there could be cost savings if the two programs jointly develop the process. However, close coordination needs to happen to ensure that the process can handle the longer MOX LTA rods and provide pellets free of added impurities if Option 3 or 4 is selected because the pellets would be reused in the MFFF process. All of these options have long time horizons either due to the protracted construction schedule for the MFFF to be operational or the establishment of fuel rod size-reduction and/or pellet removal processes at LANL.

ACTIVITY	OPTIONS				
	1 Ship fuel rods to SRS once they are able to receive the fuel	2 Ship fuel rods as waste to WIPP	3 At LANL, ship 8 fuel rods to ORNL and the remaining fuel to SRS	4 Put pellets into 3013 containers, and ship the containers to SRS for storage	5 Dispose of the fuel rods through the MR&R program
Increased MC&A and Crit. Safety Requirements		✓	✓	✓	✓
Unload FS65		✓	✓	✓	✓
Unload pellets from fuel rods/size reduce		✓		✓	✓
Size reduce fuel rods		✓		✓	✓
Single Location Shipment	✓	✓		✓	✓
Multi Location Shipment			✓		
Multiple Shipping Containers			✓		
Number of FS65s to unload	0	2	1	2	2
NRC shipping exemption for FS65	✓		✓		
Option contingent on MFFF availability	✓		✓	✓	
Expense Ranking (1 – 5, lowest to highest)	Least (If MFFF scope remains unchanged) 1	Second highest (If include fuel pellet develop. process costs) 4	Second lowest 2	Highest (If include fuel pellet develop. process costs) 5	Less than Opt. 2 (If MR&R shares process develop. responsibility) 3

Excess Equipment Options (TA-60)

In addition to the excess fuel material currently stored at LANL, the support equipment needed to unload a fuel assembly or a rod box from an FS65 is also in storage at LANL. This equipment is currently located in or next to CONEX boxes, where it is open to the elements. Three of the boxes have tarp roofs so that the large pieces of equipment in the boxes can be loaded and unloaded by an overhead crane. The other eight boxes are water tight.

The CONEX boxes that are stored at TA-60 (see Figure 1) contain handling equipment for both the FS47 and FS65 shipping containers. The FS47s were used to ship WGPu oxide that was processed at LANL to France, where it was fabricated into fuel. The FS65 containers were then used to ship the resulting MOX fuel back to the US. The FS47 and FS65 containers were the approved containers used in France at the time the shipments were made. The NRC granted exemptions for their use in the US.

Since there are no longer plans to send WGPu oxide to France, the FS47 handling equipment will be salvaged in FY16. The removal of this equipment will free up space in CONEX boxes that can be used to house some of the equipment that is currently stored outdoors in the environment.

Depending on the future plans for disposition of surplus WGPu, the FS65 equipment that is needed to unload the FS65 containers could be shipped to SRS and the unneeded components salvaged at LANL. If MOX fuel is going to be dispositioned at WIPP, all of the support equipment can be salvaged once a final course of action has been decided.



References

1. LA-CP-00-0319, *Mixed Oxide Lead Test Assembly Programmatic Lessons Learned*, September 2000
2. LA-UR-97-1359, *Development of Nonfertile and Evolutionary Mixed Oxide Nuclear Fuels for use in Existing Water Reactors*.
3. LALP-05-056, *Los Alamos National Laboratory Actinide Research Quarterly*, First Quarter 2005
4. LALP-05-056, *Los Alamos National Laboratory Actinide Research Quarterly*, Second Quarter 2005
5. ANP-10320NP, *Summary Report on Post Irradiation Examinations of MOX Fuel*, February 2012
6. LA-CP-00-233, *MOX LTA Project Risk Assessment*, July 2000
7. LA-CP-09-01731, *Decision paper for the Disposition of FS-65 Shipping Containers, Support Equipment, and Mixed Oxide (MOX) Material Contents*, December 2009
8. June 25, 2015 *Memorandum from Ernest Moniz, Secretary of Energy, to Thomas Mason, Director ORNL*
9. July 7, 2015 email from Email from Bridget Ames, WIPP, to Tracy Wenz, LANL, Subject: Fuel Rod Disposal
10. DOE OEM Accident Investigation Report, Phase 1 Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014, April 2014
11. PA-PLAN-01094, *ARIES Oxide Production Program Legacy Inventory Risk Reduction Plan*, 2014
12. PA-AP-01100, *ARIES Legacy Inventory Risk Reduction Program*, February 25, 2015